

PSYCHOLOGY 305

COGNITIVE PROCESSES

Hemispheric specialization

Page 120~150

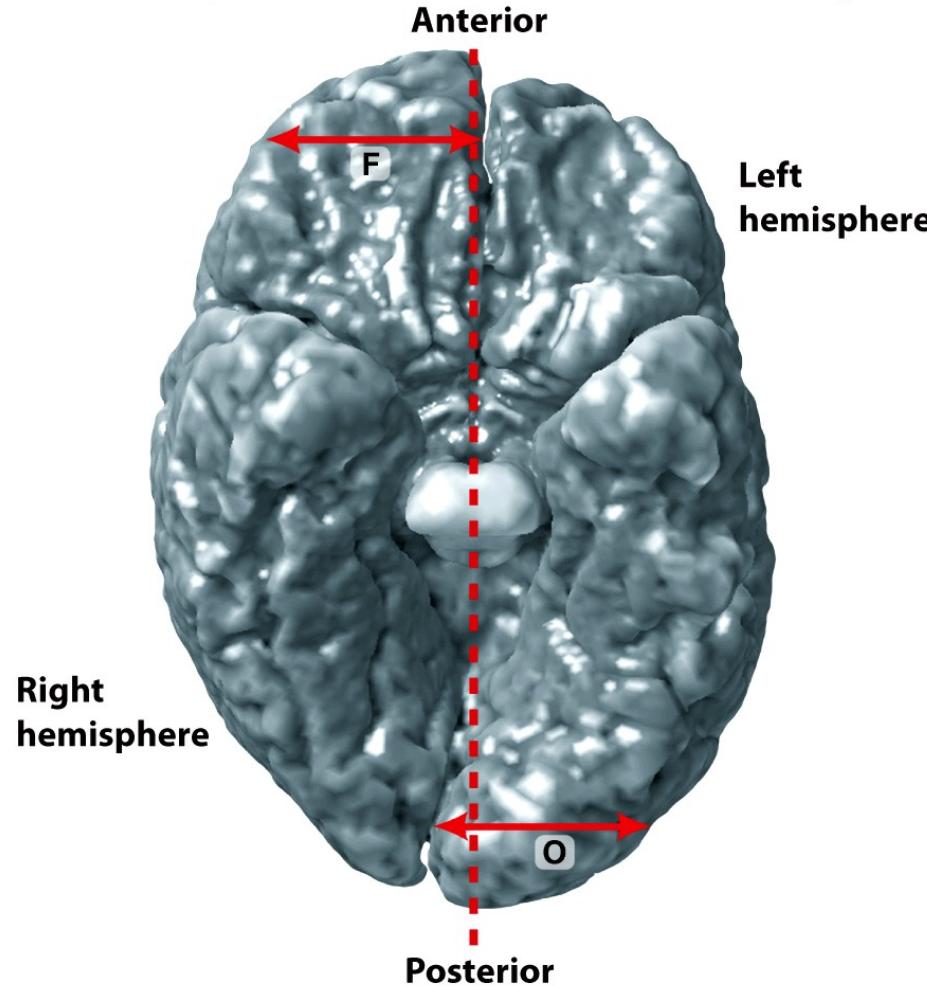
1. No Quiz
2. Corpus callosum
3. Split-brain studies
4. Functional asymmetry in ventral pathway
5. Functional asymmetry in dorsal pathway

QUIZ

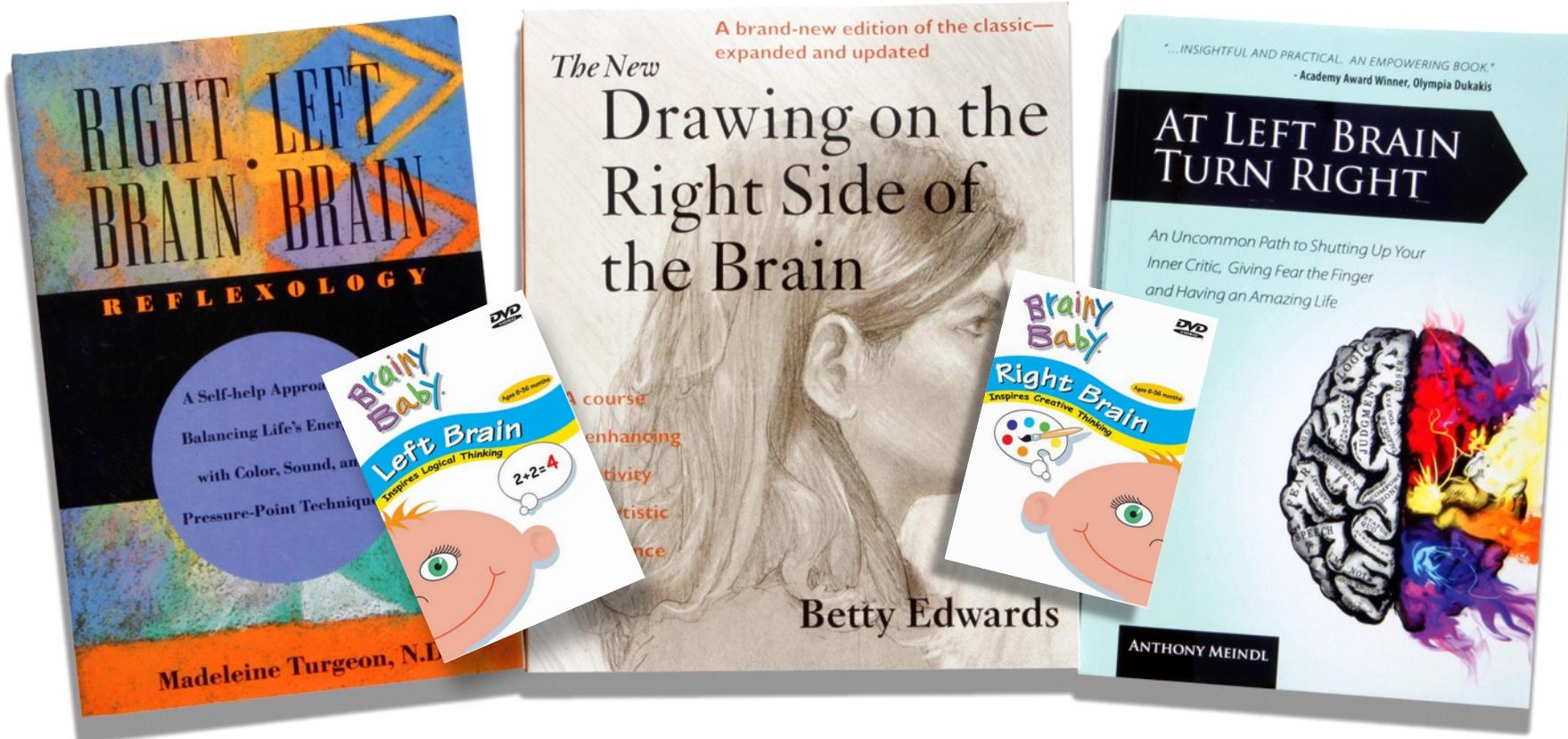
1. As you move up the ventral pathway, the _____ increases.
 - a. Size of the receptive field
 - b. Size of the visual field
 - c. Complexity
 - d. All of the above
 - e. Both a and c
2. What is difference between face and object recognition?
 - a. No difference
 - b. Faces are processed as a whole, objects are processed as a whole and by parts
 - c. Faces are processed by parts, objects are processed as a whole
 - d. Faces are processed as a whole, objects are processed by parts only
3. What are the differences between the two hemispheres?

Not Completely Symmetrical

Anatomical asymmetries between the two cerebral hemispheres



Folk psychology: left brain is analytic and the right brain is creative.

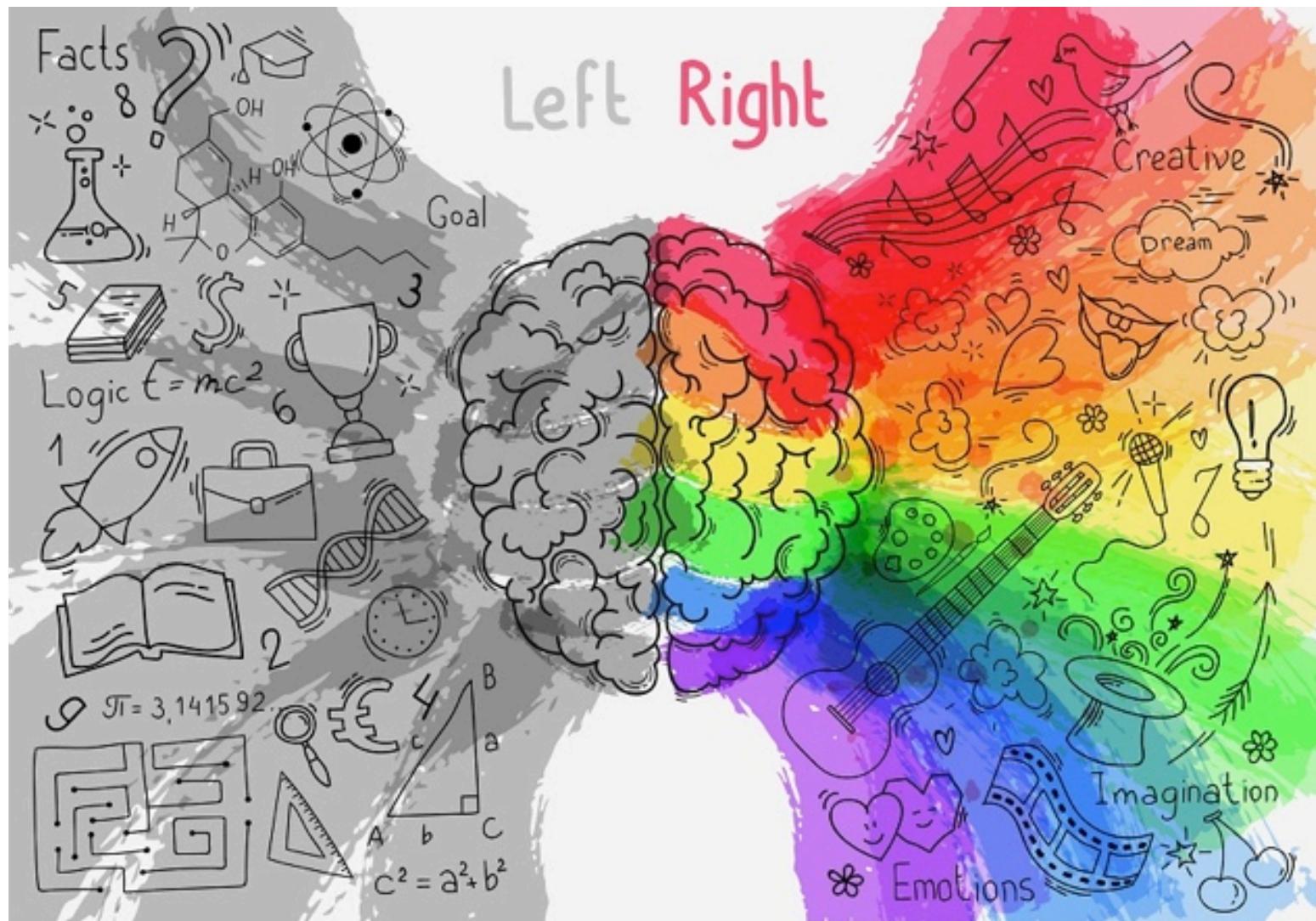


Are you a Left-brainer or Right-brainer?



- Fold your arms in front of the chest
 - a left-brainer: right arm above your left arm,
 - a right-brainer: left arm above your right arm,

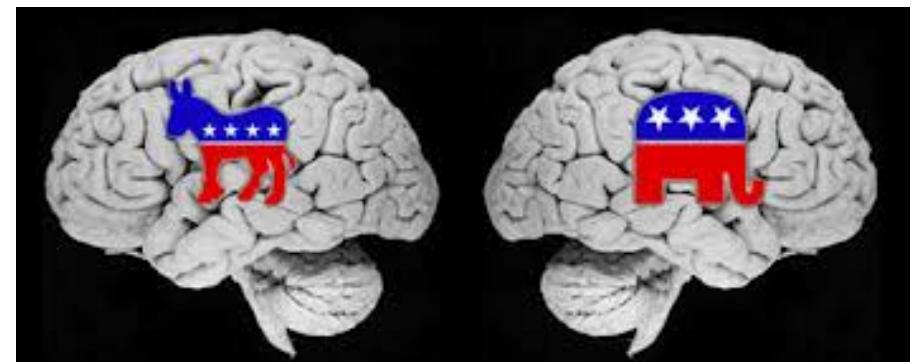
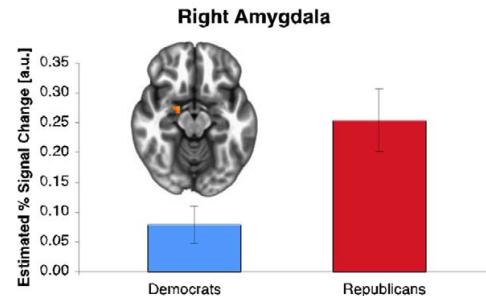
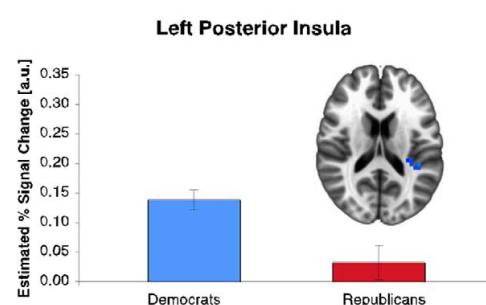
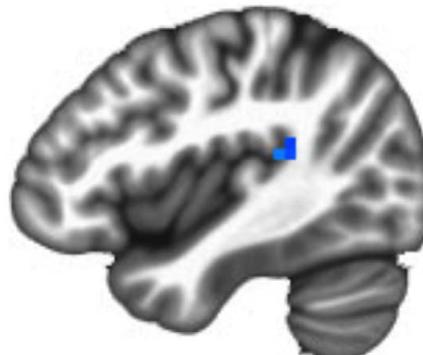
Brain hemisphere differences



Political Brain

Schreiber et al. (2013)

- Democrats: activity in the left posterior insula
- Republicans: increased activities in the right amygdala
- Can predict one's political affiliation with 82.9% of success rate!
- Neuromarketing & politics
- E.g., Republican candidates appearing on the left side in campaign video

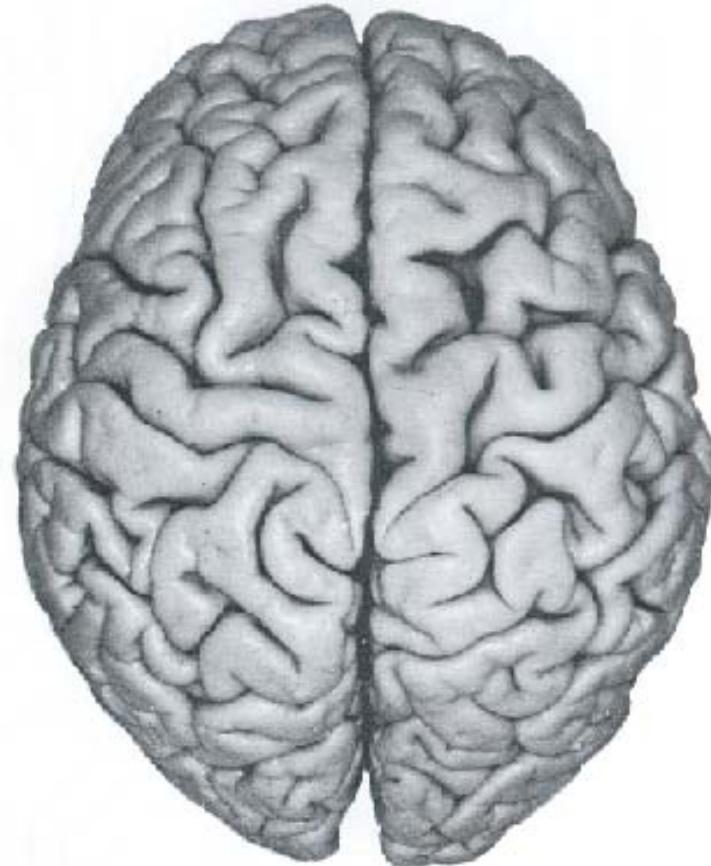


Hemispheric Asymmetries: True or False?

- How much can we trust these?
- Need to understand the hemispheric asymmetries and their cognitive effects

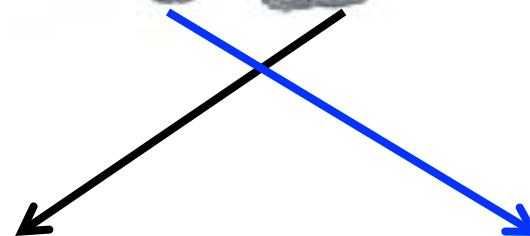
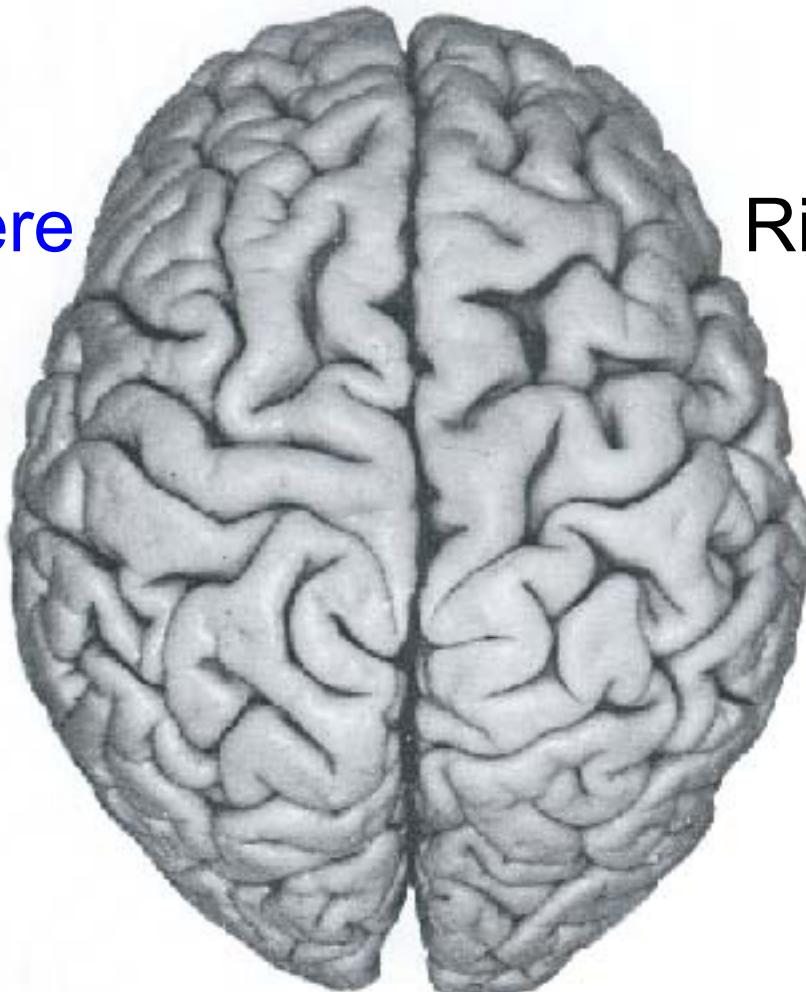
Experimental design: hemispheres

- How do you test the difference?



Left Hemisphere

Right Hemisphere

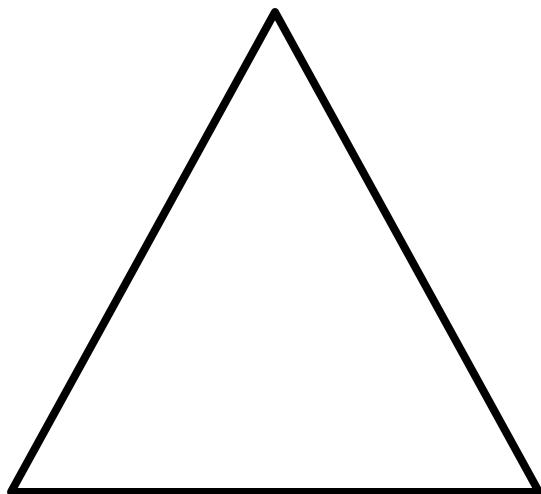


Left hand

Right hand

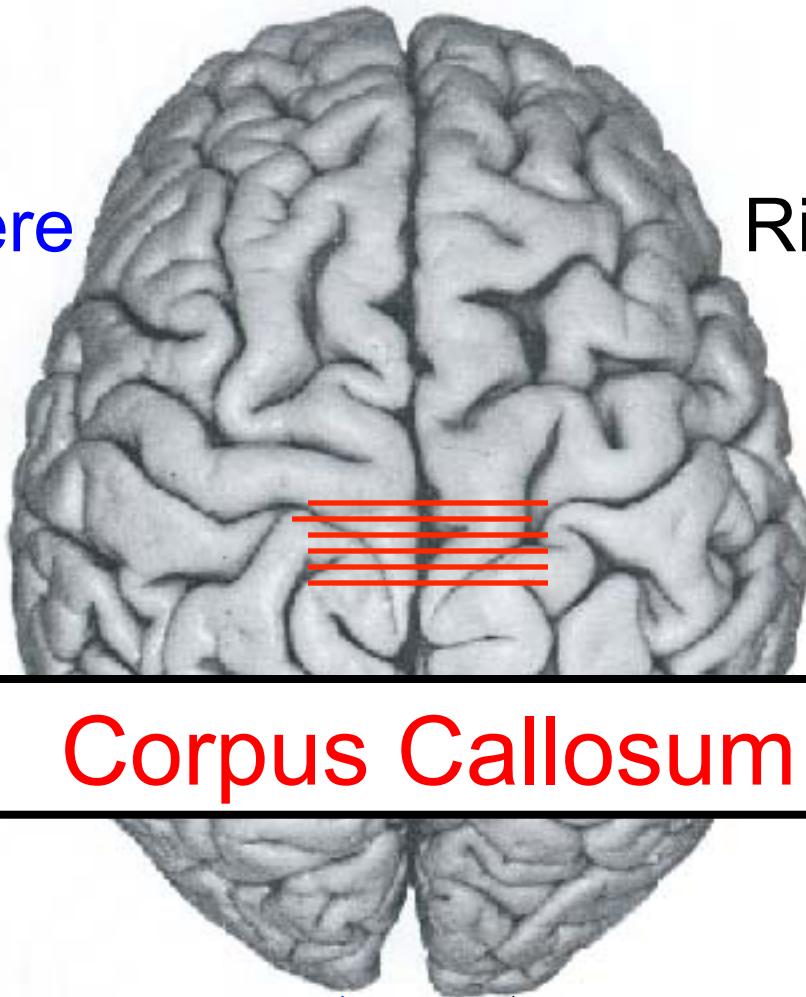
Experimental design: hemispheres

- How do you test the difference?



Left Hemisphere

Right Hemisphere



Corpus Callosum

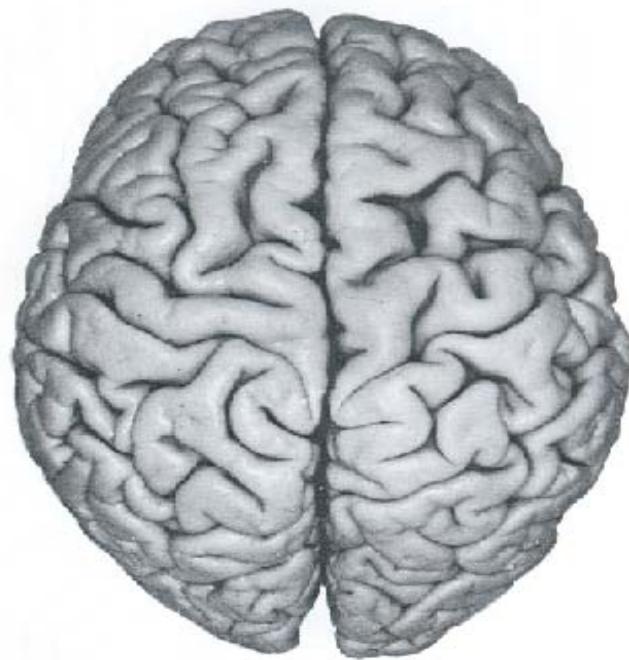
Left hand Right hand

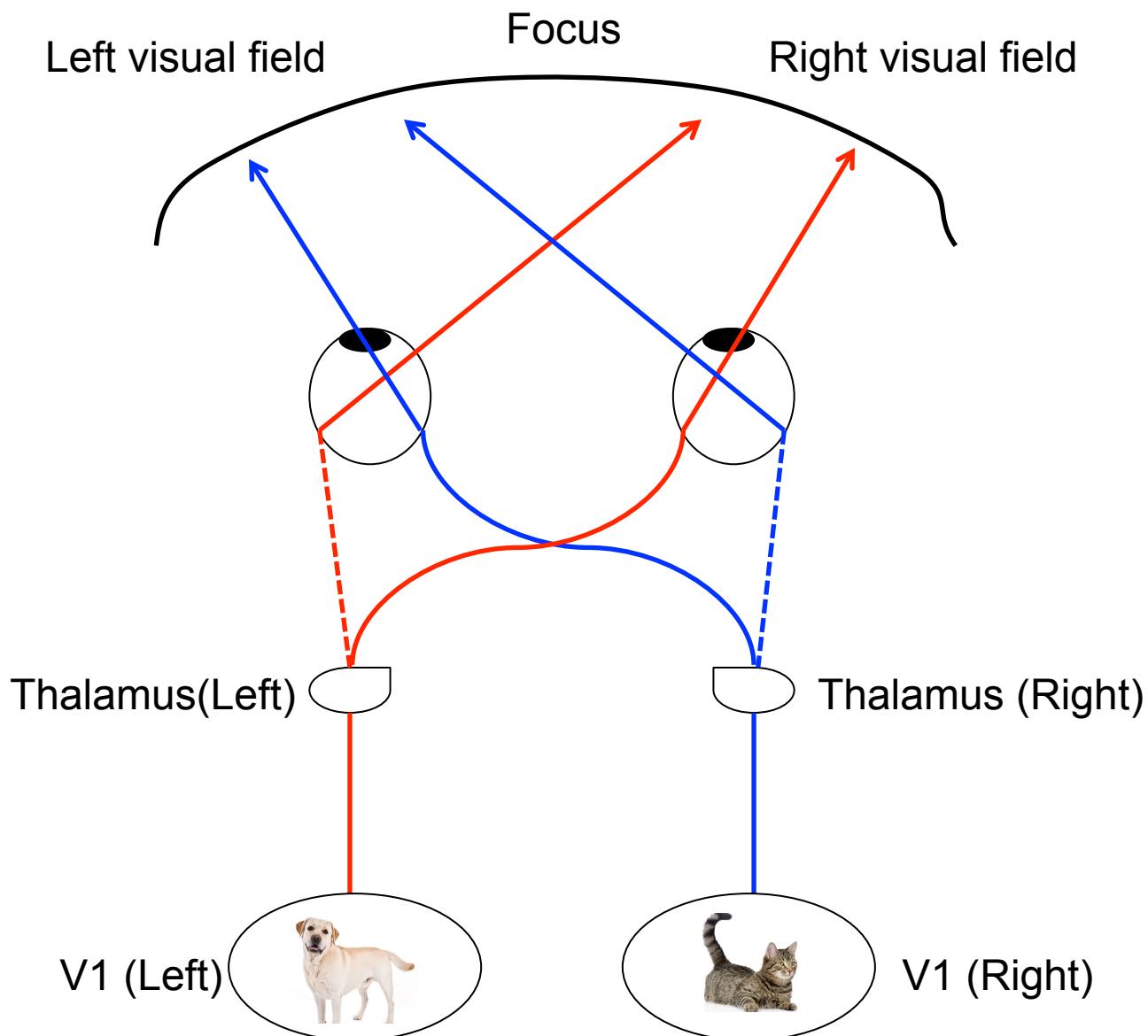


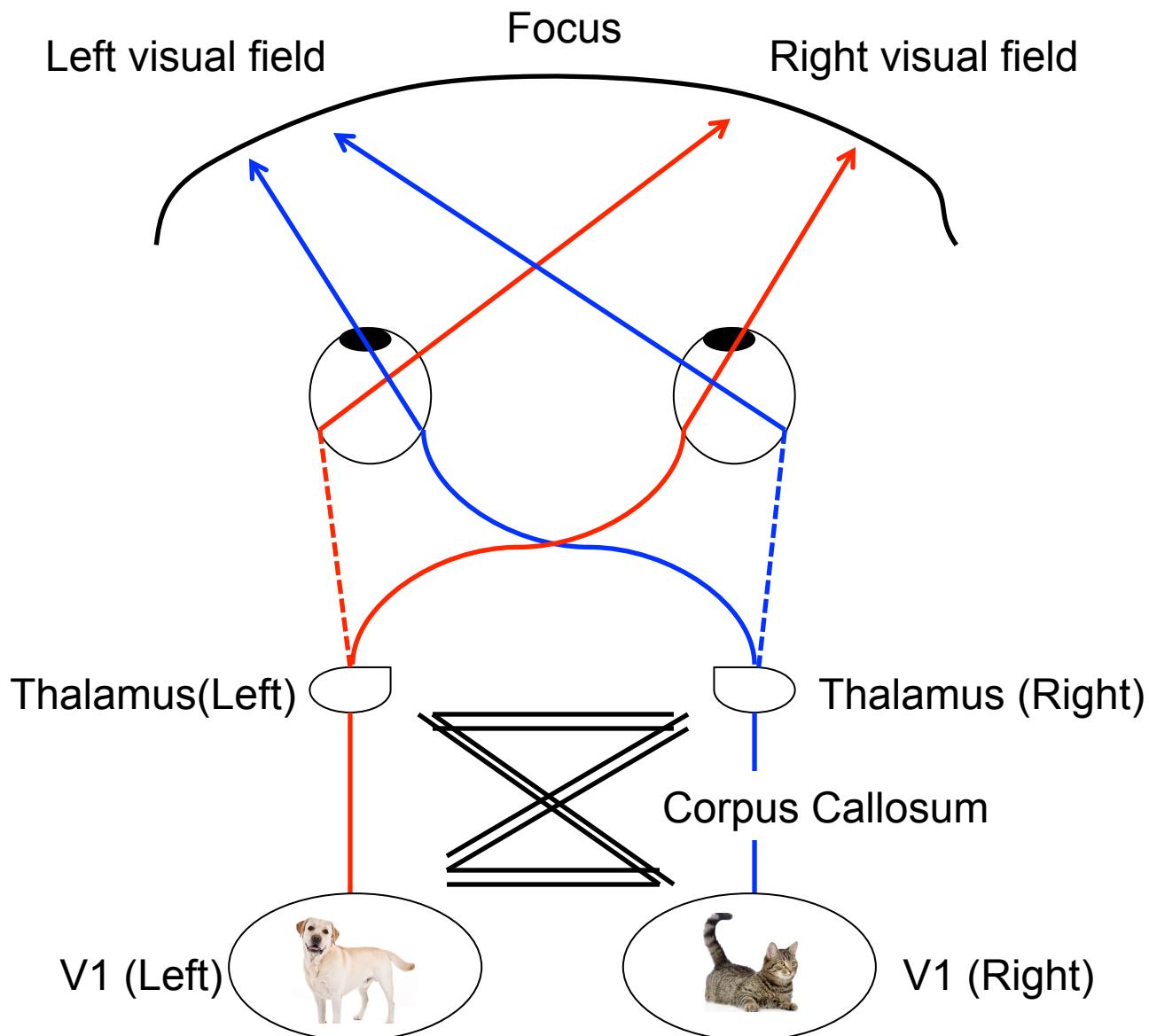
Left visual field

Focus

Right visual field

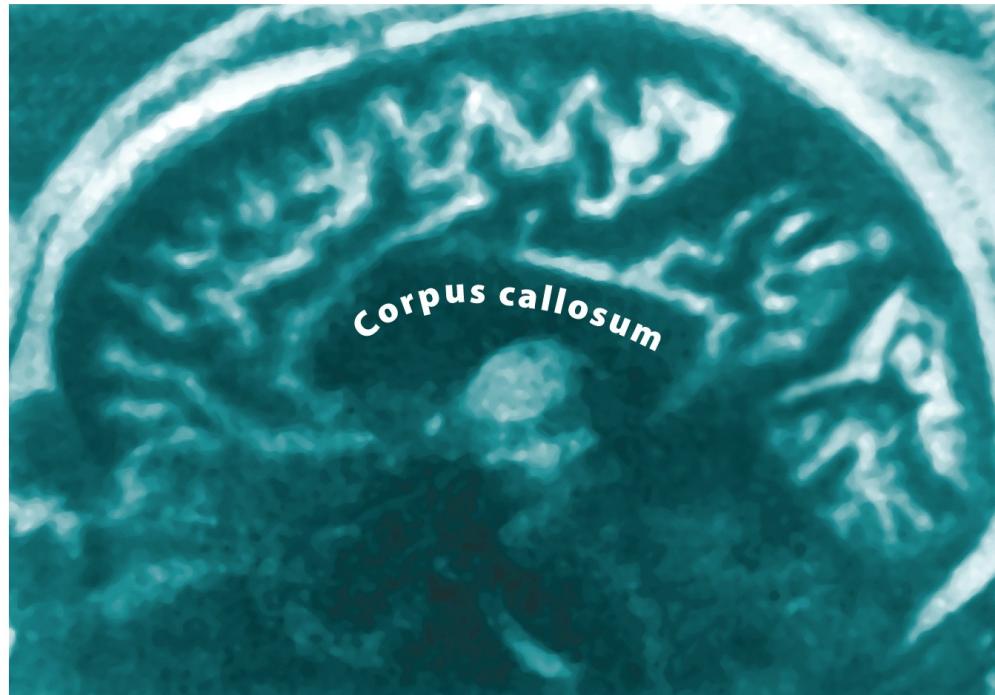




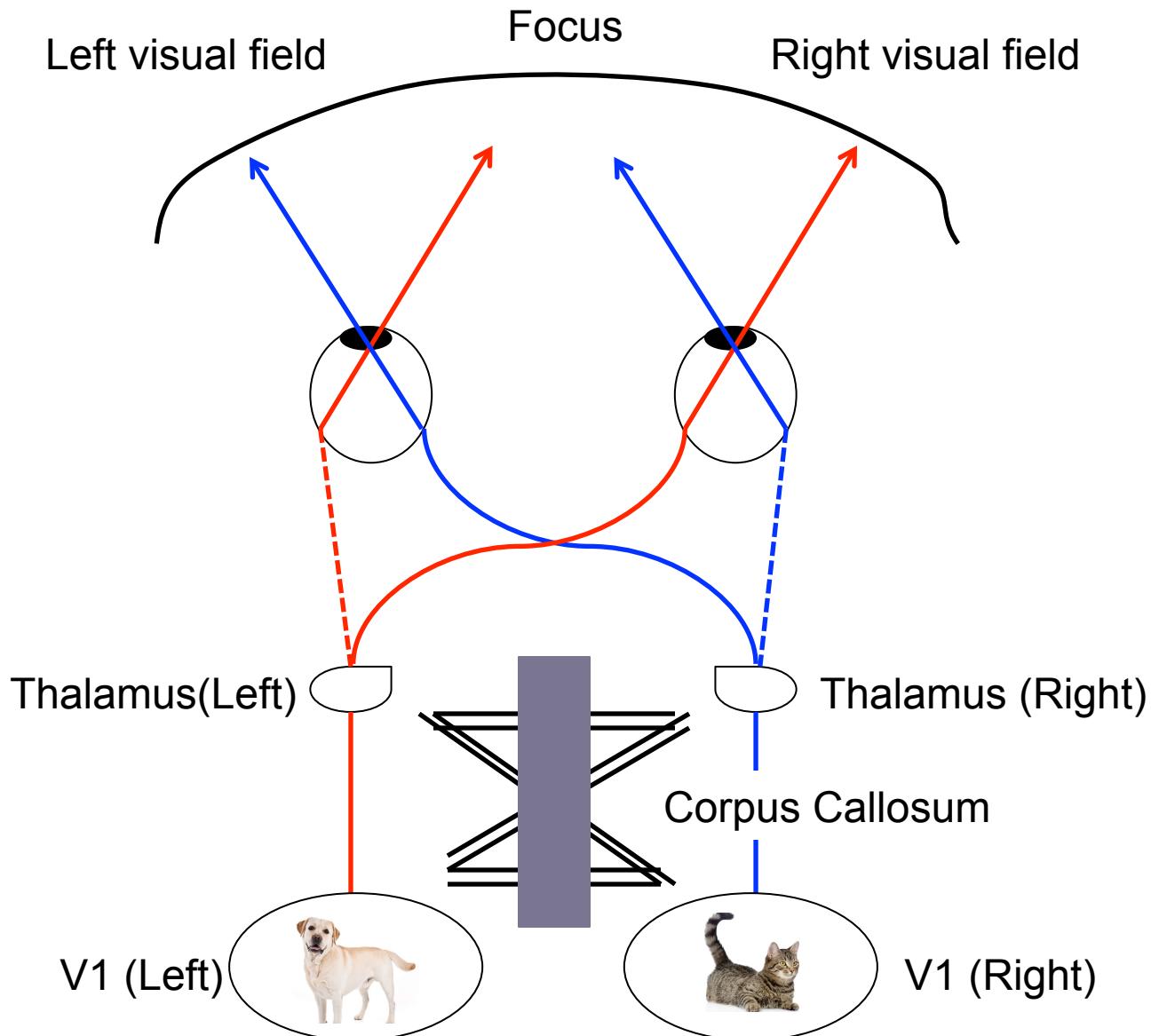


Split Brain Patients

- Surgery for epilepsy¹
 - Cut the CC to prevent seizures from jumping to other hemisphere



¹Roger Sperry & Mike Gazzaniga, 1960's

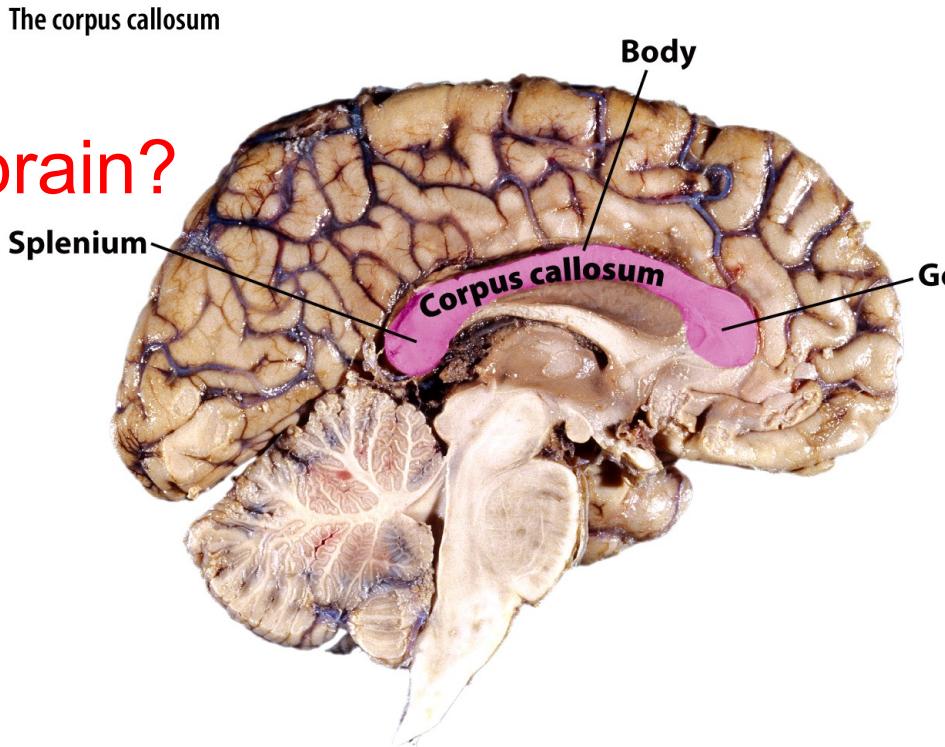


Corpus Callosum

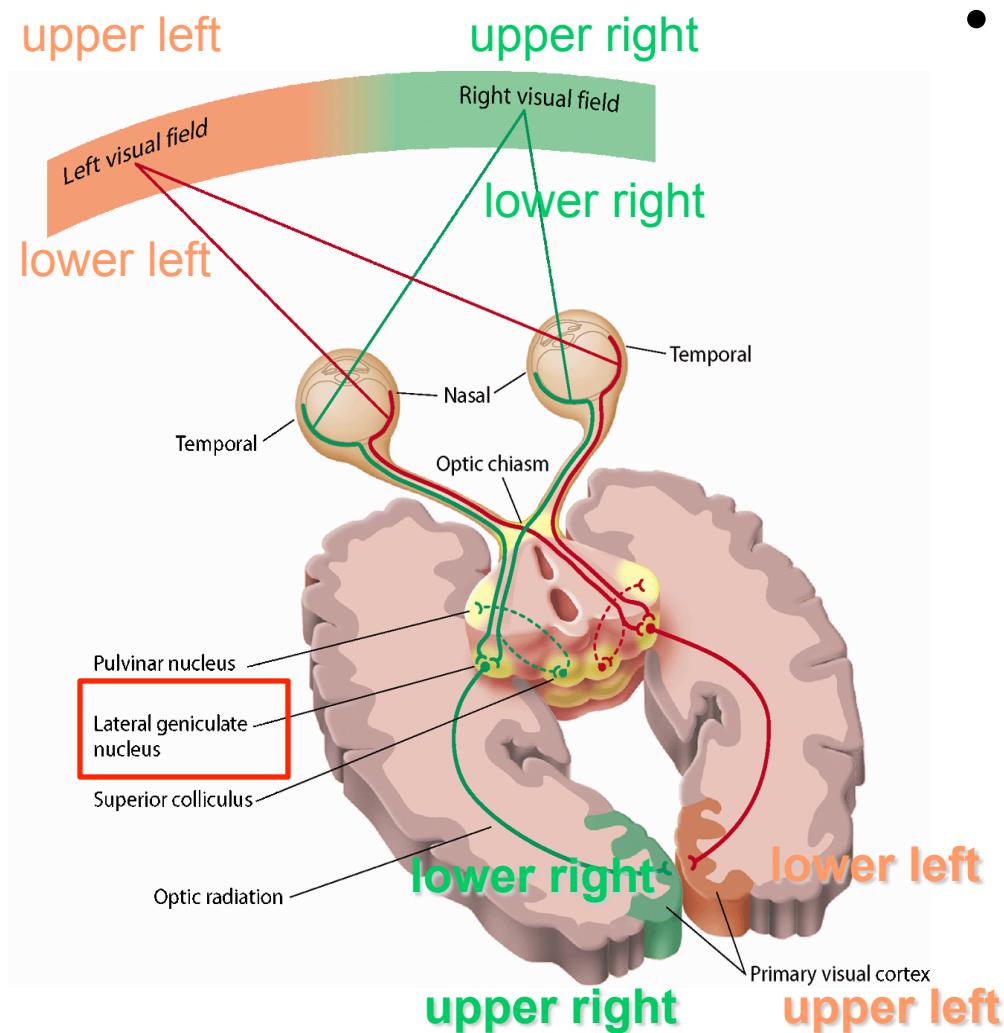
- The hemispheres of the brain are distinct yet connected
- Major pathway between hemispheres
- Major fiber tract for interhemispheric communication
- Transcallosal information transformation takes time.

Left or right brain?

Medial surface of
left hemisphere

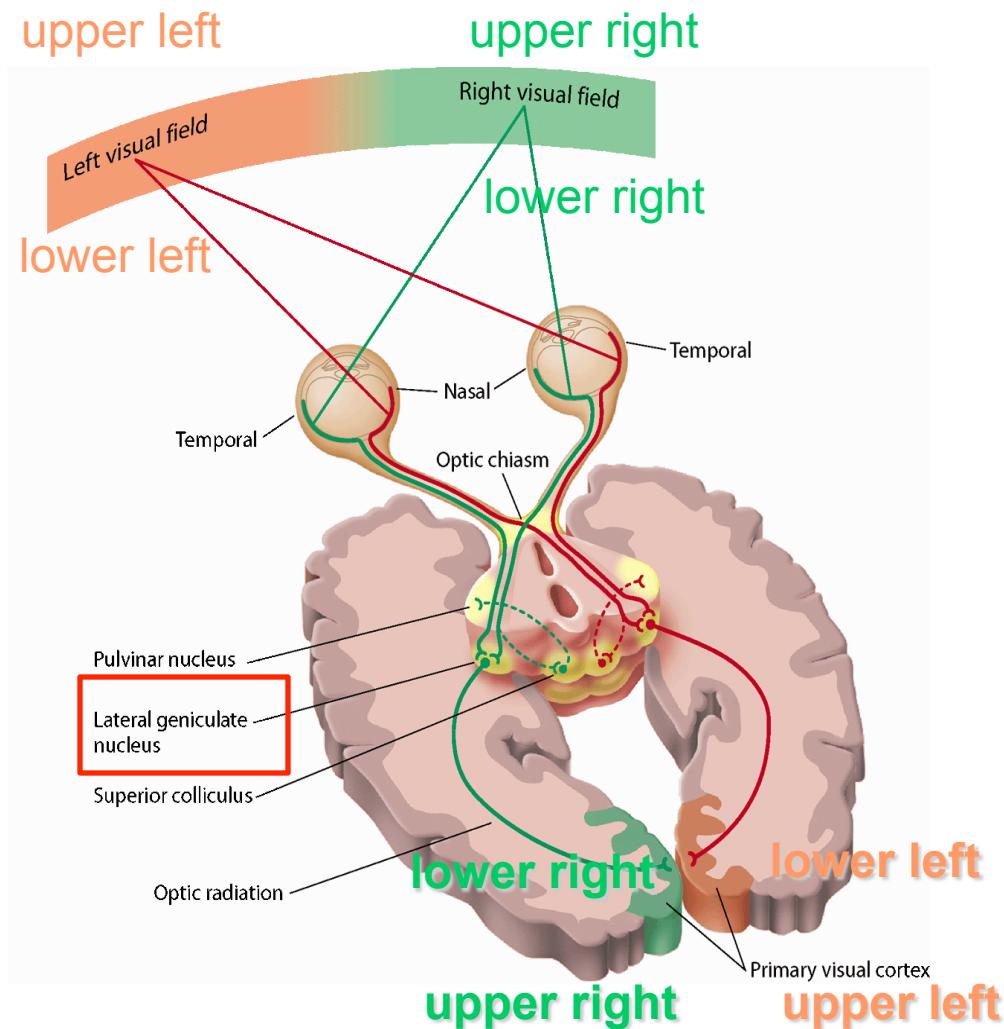


Visual cortex



- How do we use this to test hemisphere specialization?
 - Eye movements change visual field
 - Solution:
 - Eyetracking
 - Fast display <200ms
 - Faster than eyemovements

Visual cortex



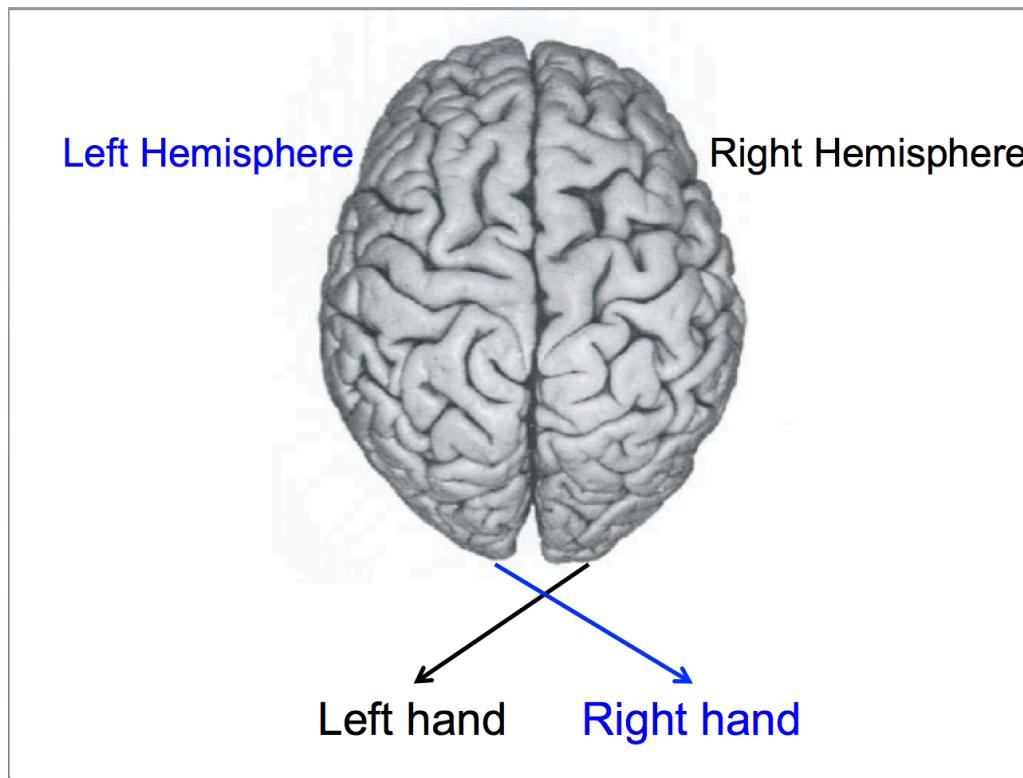
- If they move their eyes, the visual field will shift
- Need to control eye movements
 - Eye tracking
 - Fast display (faster than eye movements)

What happens when the CC is cut or disrupted?

- Each hemisphere still gets contralateral sensory input.
 - e.g. Information from left visual field goes to right hemisphere.
- Motor cortex in each hemisphere still controls contralateral side of body.
 - e.g. Commands from left M1 control right hand.
- BUT hemispheres can't communicate.
- Provides opportunity to present information to only one hemisphere and see if it gets processed.

Think, pair, share

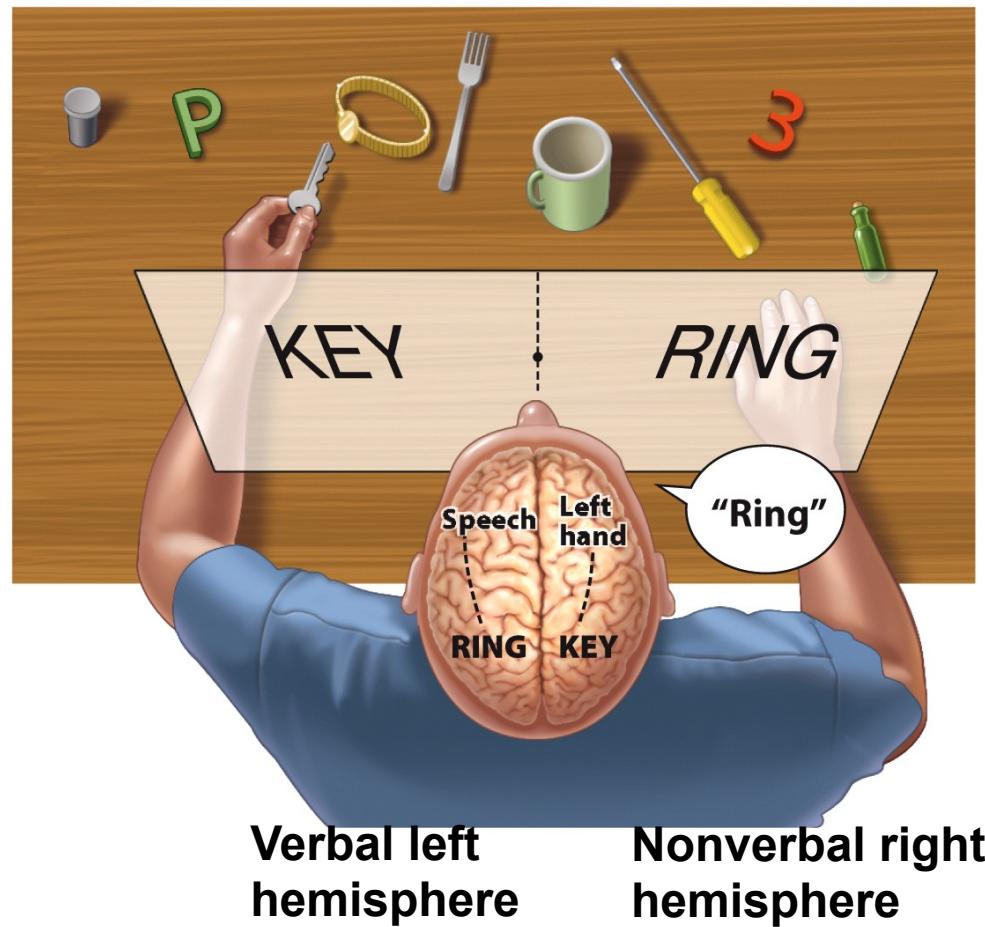
- Design a study to determine which hemisphere is involved in language production.



Language in LH

Special apparatus

- Screen blocks objects on table from view
- Picture input to just one side of brain
- Hands to identify objects by touch



Language in LH

Exp'ter: What did you see on the screen?

JW: Ring

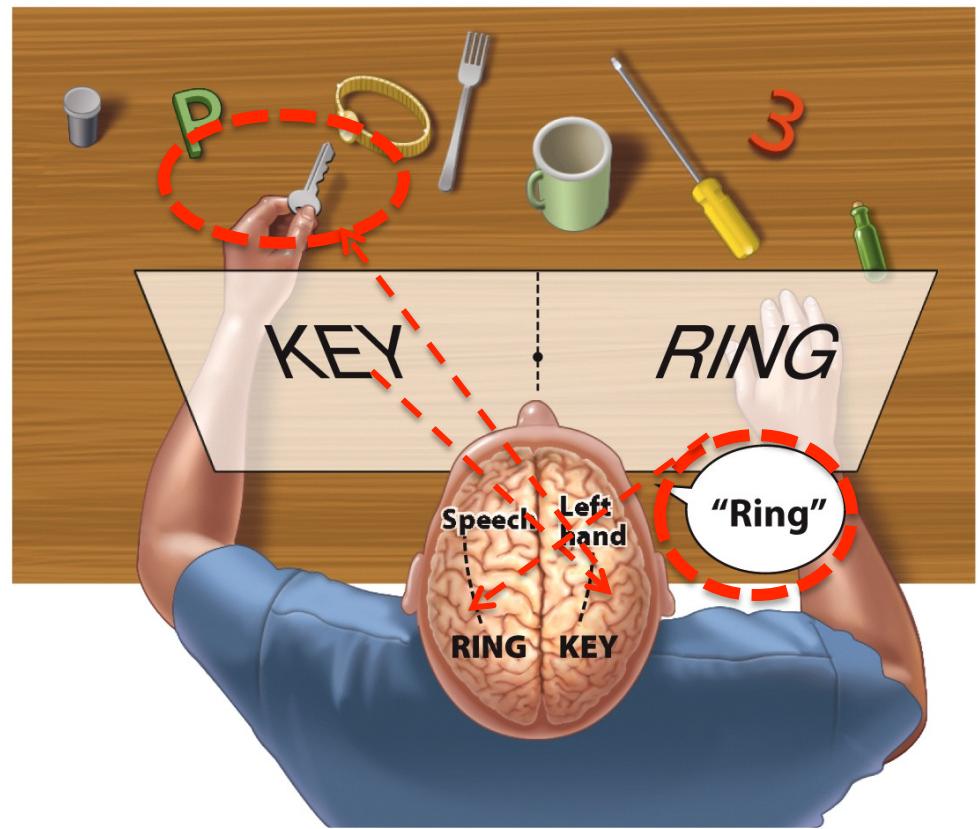
Exp'ter: Anything else?

JW: Nothing

Exp'ter: Pick up the object with your left hand

JW picks up the key

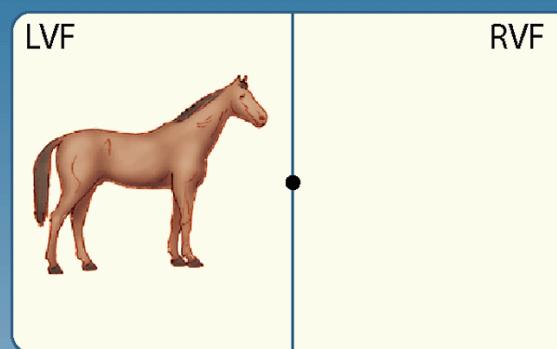
Only the LH can *produce* speech, but the RH has some basic language *comprehension*



Language in RH is limited

(a)

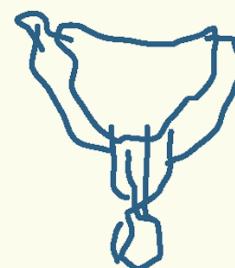
Visual stimulus



Examiner: "What was it?" "What goes on it?"

Verbal response: "I don't know." "I don't know."

Left-hand drawing:
(saddle)



RH has some comprehension, but no speech generation (as a rule).

Write the word with the ipsilateral hand and name it

RH: can write the LVF word, unable to name it

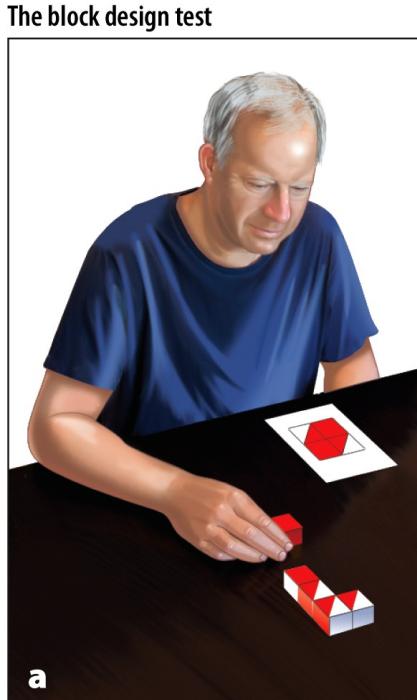
LH: can name the RVF word, unable to write it



Spatial Task in RH

- Coordination of motor plans disrupted in split-brain patient, resulting in competition.
- The spatial figure construction task
 - is perfect with his left hand (right hemisphere, RH, wins)
 - but fails with his right hand (left hemisphere, LH, wins, thus inhibiting the RH)

LH: left hemisphere
Right hand



RH: right hemisphere
left hand

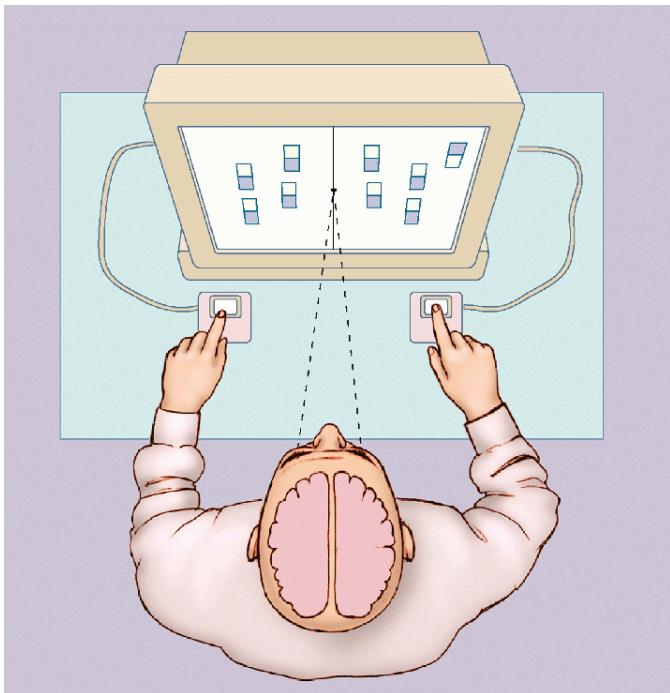
Just impairments?

- Is there any advantage to having two separate hemispheres?

Split-brain Patients: Double the Mind

Power?

- TASK: search for combination of two features
- Split-brain patients perform visual search tasks twice as fast as normal participants
- Suggests that each hemisphere has its own mind



Split brain studies in humans

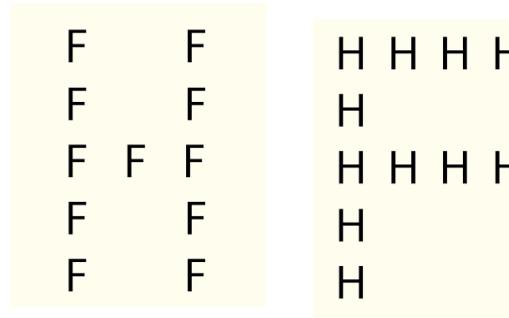
- Contributions:
 - Functional specifications
 - LH for language production, analytic
 - RH for visual-spatial processing and action
 - Each hemisphere can function independently (to some degree)
 - Even double cognitive capacity
 - No cross-hemisphere communication, with some residual cross-task via subcortical pathway
- Limitations:
 - Patients are not “normal” prior to surgery
 - Typically with extreme epilepsy
 - Findings are from a handful of patients
 - Brain imaging studies show that both hemispheres contribute to all functions but to a different degree

How can we study hemispheric specialization in normal cognition to test theories?

- Transcallosal information transformation takes time
- Visual half-field presentation without eye movements
 - Short exposure duration (under 200 ms) or fixation monitoring



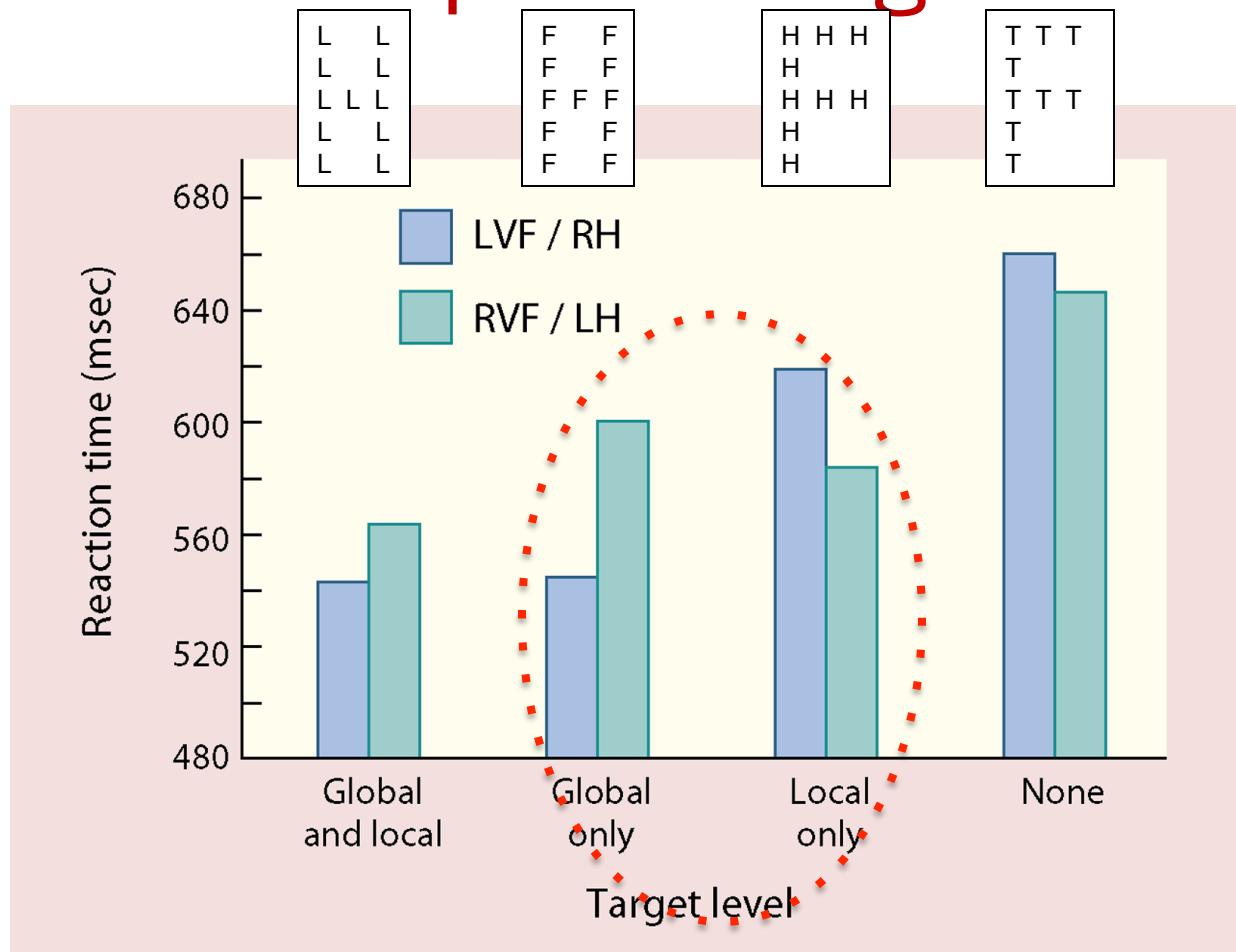
Ventral pathway - Local vs global processing



Navon Task:

- name global letter or
 - name local letter
- RTs faster for global

Ventral pathway - Local vs. global processing

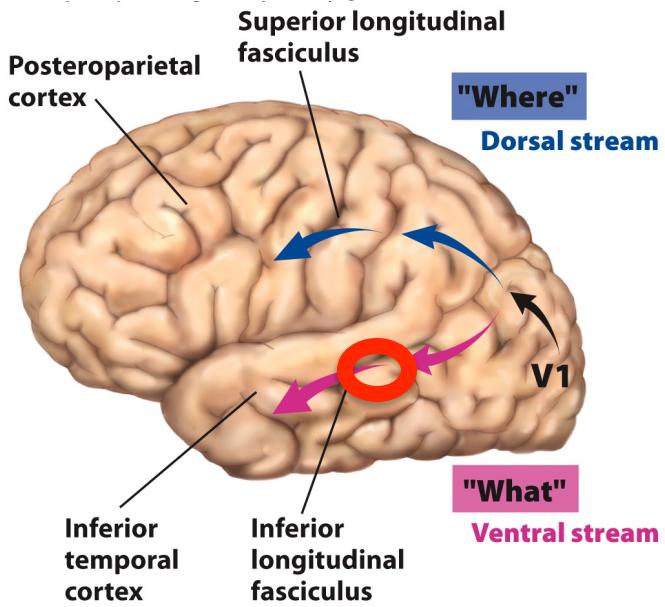


TASK: does the stimulus contain either an H or L?

RH better at global level, LH better at local level (but either can do task)

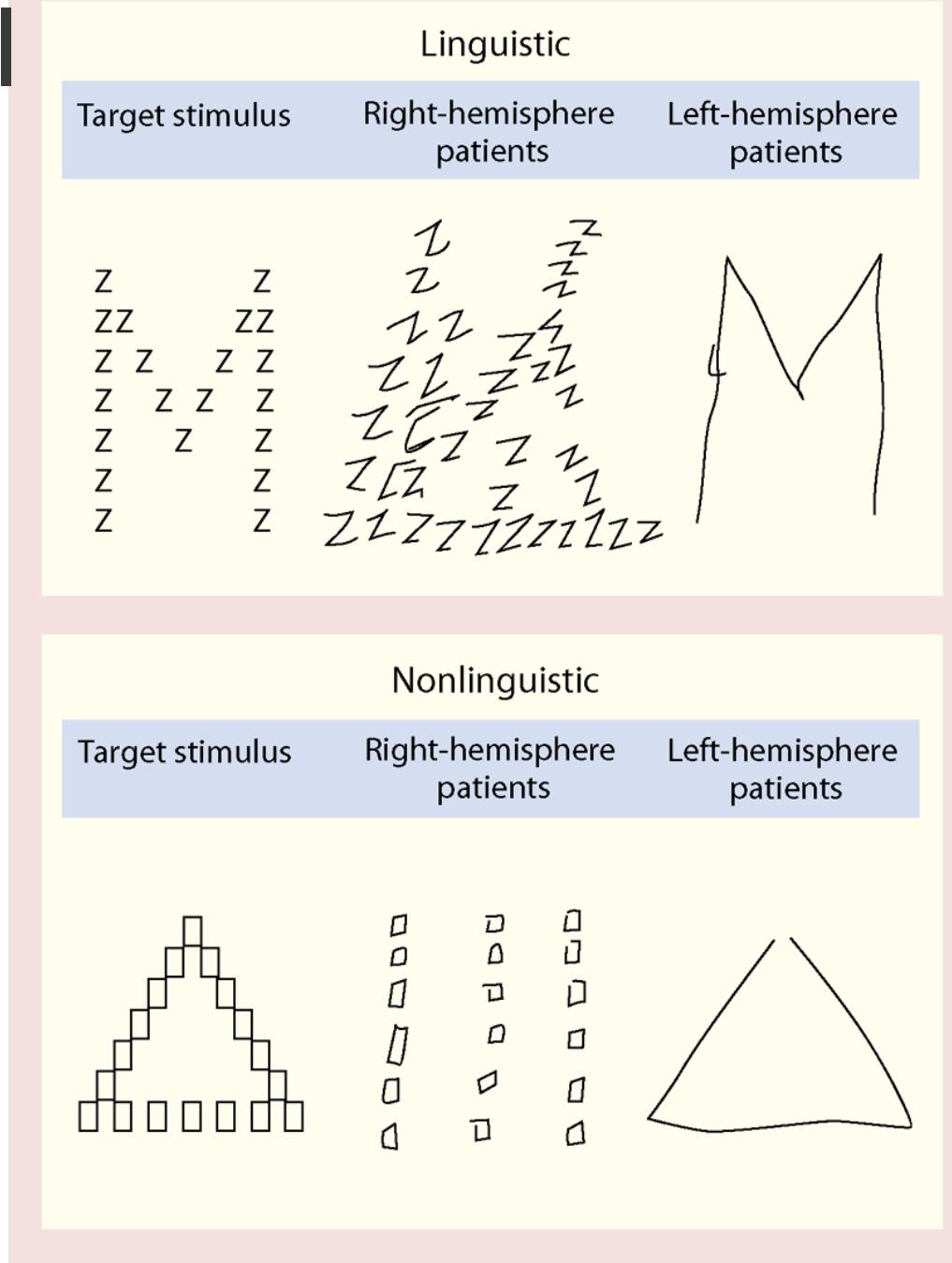
Local vs global processing

Unilateral lesions of temporo-parietal junction (what pathway)



LH patients: impaired at local processing

RH patients: impaired at global processing



Basis of global/local dissociation?

Spatial frequency hypothesis

- Spatial frequency
 - Level of detail present in a stimulus per degree of visual angle

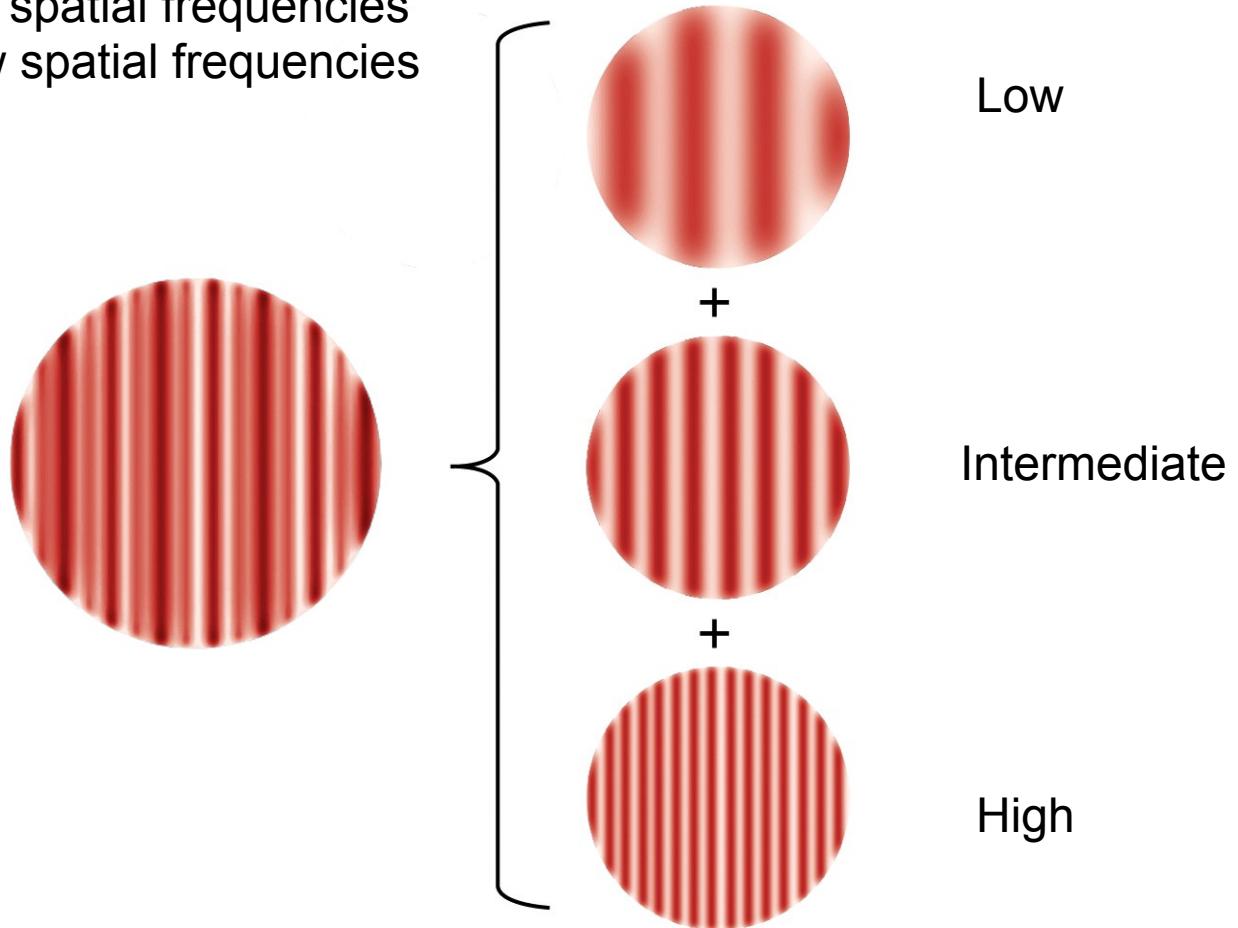


Basis of global/local dissociation?

Spatial frequency hypothesis

Perception involves processing different spatial frequencies

- local level based on high spatial frequencies
- global level based on low spatial frequencies



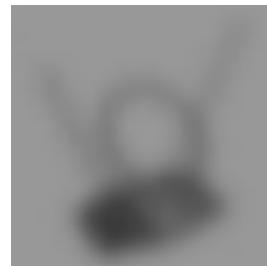
Ventral pathway: Spatial frequency hypothesis

- LH - better at processing high spatial frequency information
 - Allows perception of details/edges (local)
- RH - better at processing low spatial frequency information
 - Allows perception of whole/overall shape (global)



*Intact
LSF+HSF*

=



LSF (blob)

+



HSF (edge)

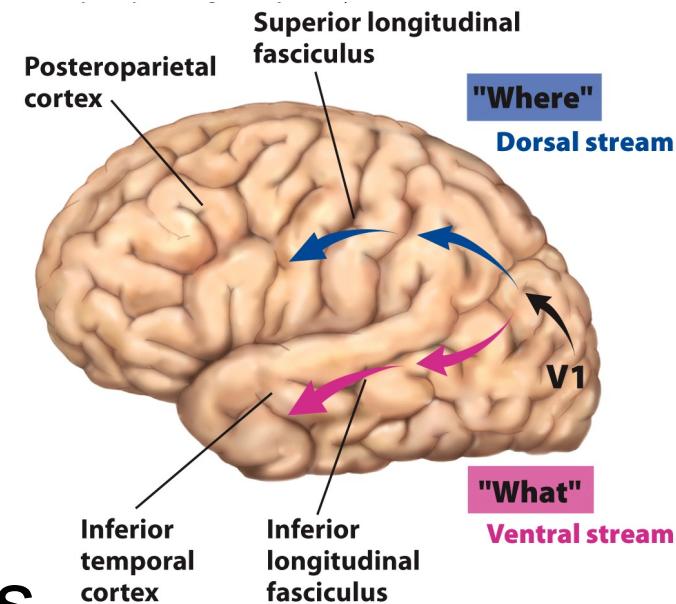
Hemispheric specialization

- we've talked about specialization in the “what” pathway (stimulus identification)

LH: local processing (high spatial frequency)

RH: global processing (low spatial frequency)

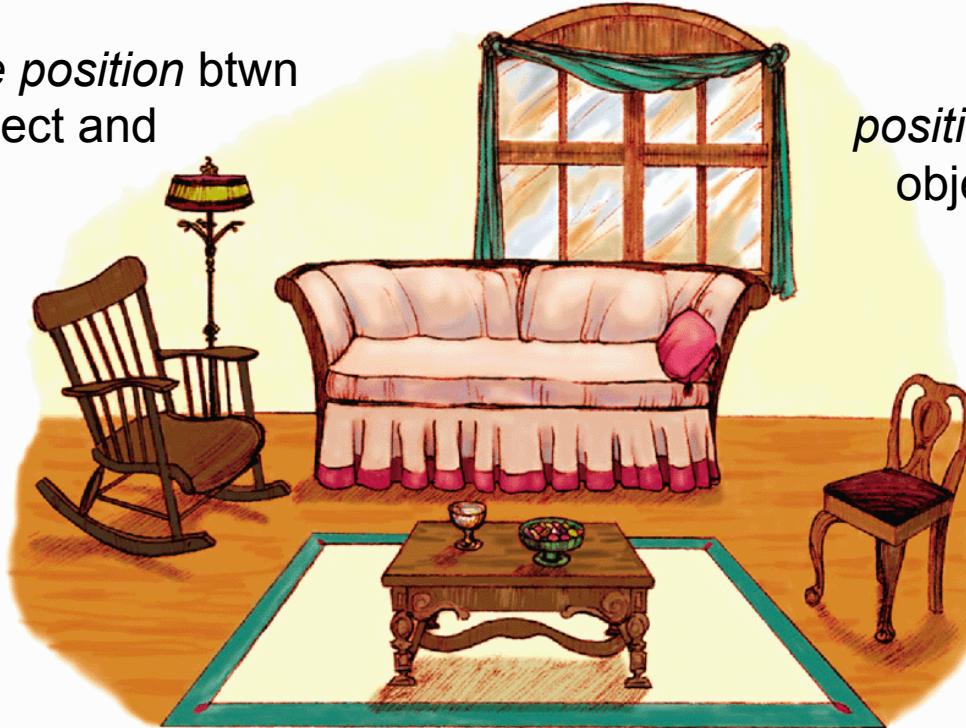
- “where” pathway?
 - stimulus spatial relations



Categorical vs Coordinate Reps

Specify the *relative position* btwn objects or btwn object and viewer

Specify the *exact positions and distances* btwn objects or btwn object and viewer



Categorical representation

Rocking chair left of couch
Dining chair right of couch

Coordinate representation

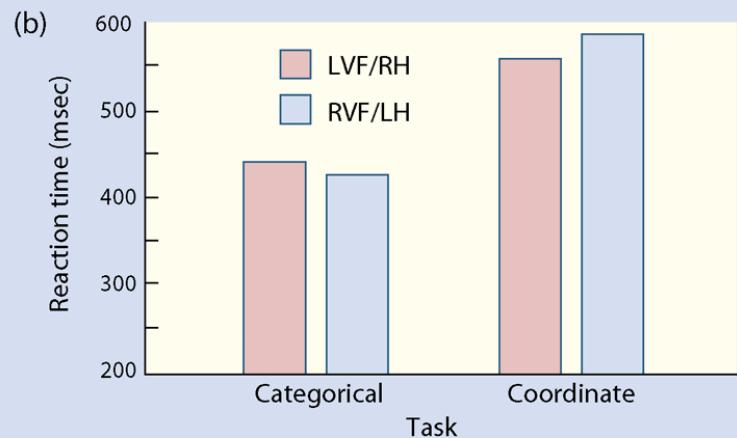
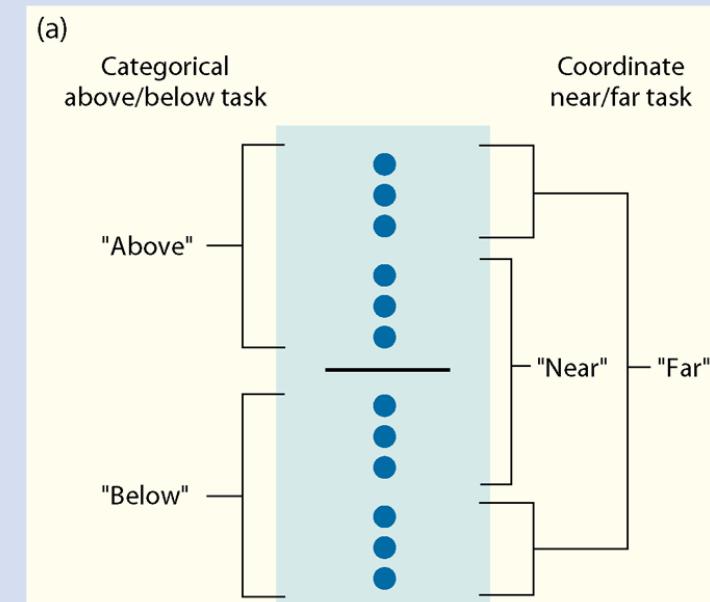
Rocking chair 2 feet from couch;
Rocking chair closer than dining chair to couch

Categorical (LH) vs Coordinate (RH) Reps

TASK 1 (categorical):
Is dot above or below line?

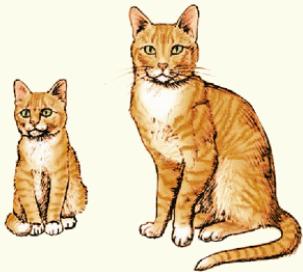
TASK 2 (coordinate):
Is dot near or far from line?

RTs faster
for categorical task in **RVF** (LH)
for coordinate task in **LVF** (RH)



Categorical (LH) vs Coordinate (RH) Reps

Target



Categorical transformation probe



Coordinate transformation probe



TASK: delayed match to sample

Patients with LH lesions worse on categorical mismatches

Patients with RH lesions worse on coordinate mismatches

Representing spatial relations:

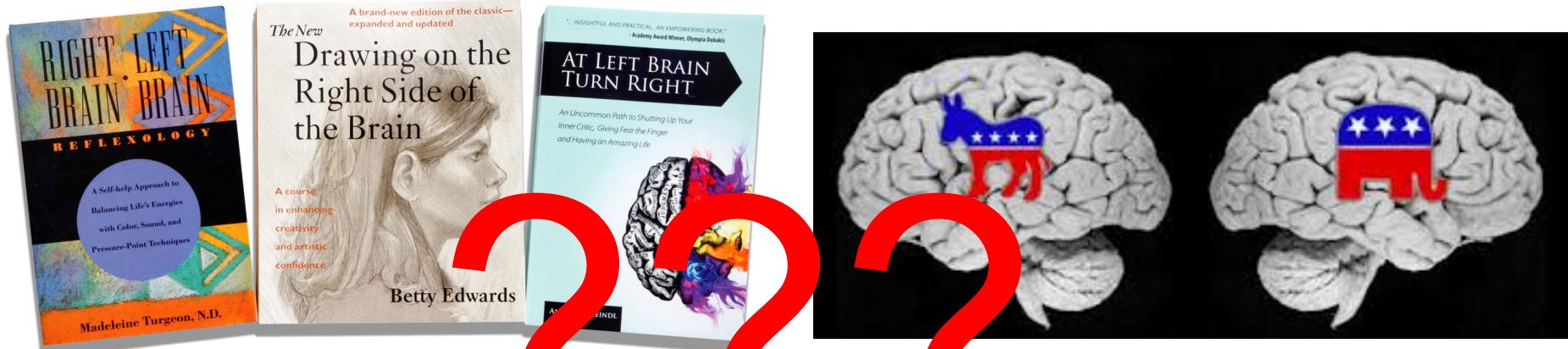
- LH: categorical relations - abstract
top/below, left/right
- RH: coordinate relations - specific
metric, relative distance

Kosslyn (1989):

LH may be specialized for categorical relations
because they can be represented in *verbal* terms

RH may be specialized for coordinate relations
because it is superior for *visual-spatial* processing

Left- vs. Right- Brainer



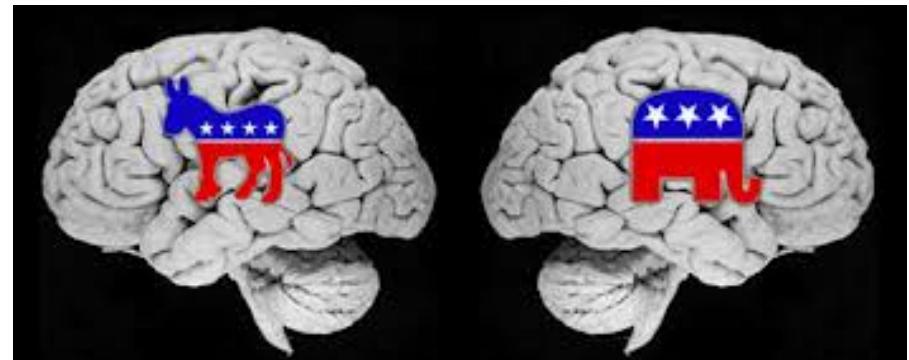
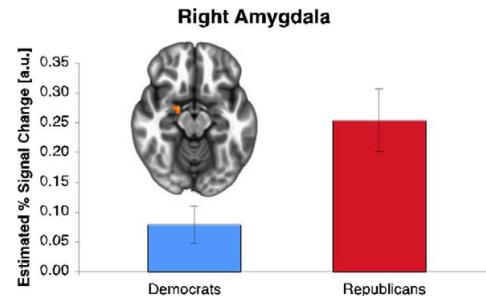
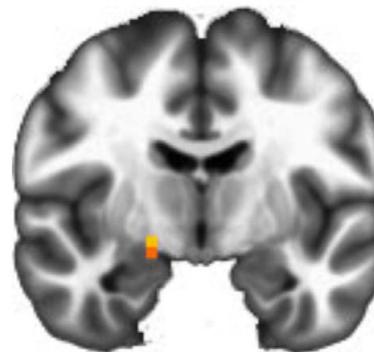
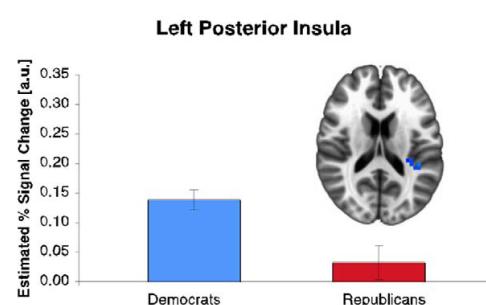
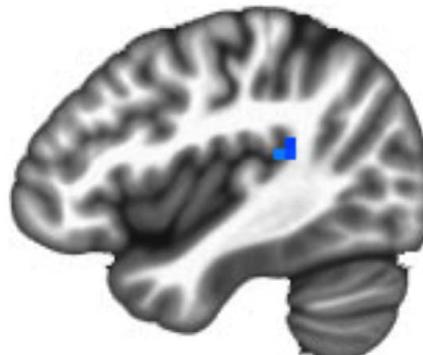
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- Cognition
 - Left brain: language
 - Right brain: visuospatial processing.
- Personality
 - left-brain: verbal, analytic, dominant, copywriter
 - right-brain: artistic, the instantaneous, “flash-of-insight”, art director

Political Brain

Schreiber et al. (2013)

- Democrats: activity in the left posterior insula
- Republicans: increased activities in the right amygdala
- Can predict one's political affiliation with 82.9% of success rate!
- Neuromarketing & politics
- E.g., Republican candidates appearing on the left side in campaign video



Not about Left vs. Right

- Not really about neural/genetic foundations for the differences in ideology.
- Rather it is about the differences in cognitive processing
- Conservatives show greater sensitivity to threatening stimuli, which is processed in amygdala (week 7).
- Liberals show greater activity in insula, the neural center for “theory of mind”, the ability to understand what others might be thinking (week 9).

Maybe Not

- Sperry warned that “experimentally observed polarity in right-left cognitive style is an idea in general with which it is **very easy to run wild**... it is important to remember that the two hemispheres in the normal intact brain tend regularly to **function closely together as a unit**” (1984, *Neuropsychologia*).
- Can be left-handed or right-handed, but no clear dominance in hemisphere.

Even a simple task involves many cognitive functions that may not be lateralized

Hemispheric Specialization

Essentials

- Language
 - RH – language comprehension only
 - LH – both language production and comprehension
- Visuo-spatial
 - RH – intact
 - LH – impaired
- Ventral pathway
 - RH – global and low spatial frequency
 - LH – local and high spatial frequency
- Dorsal pathway
 - RH – coordinate (distance)
 - LH – categorical (relative position)

Hemispheric Specialization

Essentials

- Corpus callosum
- Split-brain studies
 - LH: language
 - RH: visual-spatial and motor
- Functional asymmetry in ventral pathway
 - unifying principles
 - local vs. global (holistic) processing
 - low vs. high spatial frequencies
- Functional asymmetry in dorsal pathway
 - Categorical vs. coordinate